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Establishment of an Environmental Control Technology laboratory with a Circulating Fluidized-Bed Combustion System

Quarterly Technical Progress Report
October 1- December 31, 2006

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ABSTRACT

This report is to present the progress made on the project entitled "Establishment of an Environmental Control Technology Laboratory (ECTL) with a Circulating Fluidized-Bed Combustion (CFBC) System" during the period October 1, 2006 through December 31, 2006. The effort has been primarily concentrated on installation of CFBC Facility and preparation for cold fluidization operation. The assembly of the ash recirculation path from the cyclones back to the bed area of the Combustor has nearly been completed. Wind box assembly, including ash "drain"oulet, cast refractory "bowl" under the bubble nozzles and bed pre-heater has also been completed. Materials for flue gas duct from secondary cyclone to induced draft fan inlet have been specified and ordered. A laboratory-scale waste incineration test was conducted with two waste pellets. The purpose of this test is to characterize the by-products generated during the incineration.

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1. EXECUTIVE SUMMARY

The effort has been primarily concentrated on preparation for cold fluidization operation, although progress has been made on other tasks. The assembly of the ash recirculation path from the cyclones back to the bed area of the Combustor has nearly been completed. Wind box assembly, including ash "drain"oulet, cast refractory "bowl" under the bubble nozzles and bed pre-heater has also been completed. The secondary combustion air blower and variable speed drive have been received and are ready for installation and connection to the four levels of secondary air injection. Further, the induced draft fan has been ordered and is due to arrive on January 31st, 2007. Finally, materials for the flue gas duct from secondary cyclone to induced draft fan inlet have been specified and ordered.

A laboratory-scale waste incineration test was conducted with two waste pellets. The purpose of this test was to characterize the by-products generated during the incineration.

2. EXPERIMENTAL

2.1 Installation of the CFBC Facility

Installation of the circulating fluidized-bed combustor (CFBC) continues during this period. The specific tasks completed during this period are:

a) All ash recirculation ducts have been aligned and installed, including four thermal expansion joints and duct support hardware.
b) Both loop seals have been installed in ash recirculation path.
c) Cold ash supply duct has been installed, including one thermal expansion joint.
d) Induced draft fan has been specified, ordered and is now forecast to arrive on site January 31, 2007. The shaft seal manufacturer had problems producing the required shaft seal and delayed the fan manufacturer's delivery for more than a month.
e) Installation of the induced draft fan power supply and variable speed drive has been completed.
f) Secondary combustion air blower has been received and it's power supply and variable speed drive installation is complete.

g) Secondary combustion air distribution control valves have been received.

h) Flue duct from secondary cyclone to induced draft fan inlet and the induced draft fan discharge duct have been designed, components specified and ordered.

i) Wind box installation, including cast refractory "bowl" that helps shape fluidization pattern at bubble plate nozzles has been completed.

j) Lower level bed ash drain outlet has been completed. Rapid bed ash drain flange has been capped with a blind flange.

k) Assembly of primary combustion/fluidizing air inlet duct from supply blowers to wind box has been completed, including a bed pre-heater diverter valve.

l) Assembly of bed pre-heater that heats the fluidizing air just prior to entering the windbox is nearly complete.

m) Sensor and control signal cable raceway enclosure at control room has been completed that allows these cables to connect to the process control and data logging computer in control room.

n) Many coolant system components have been specified and ordered, including heat exchanger flow control valves, pumps, expansion tank, gas/liquid separator and major water supply piping.

Table 1 lists all construction tasks and the estimated percent complete for each.

Table 1. CFBC Construction Progress Information

Task Area	Specific Activities	Estimated Percent Completed
Ash (Hot & Cold) Supply Ducts	Assemble Ducts, Solids Bend, Thermal Exp. Joints, Loop Seals	70
Primary Cyclone Support	Assemble support, align to ash ducts and secondary cyclone	100
Secondary Cyclone Support	Assemble support, align to ash ducts	100
Fuel/Bed Material Supply Ducts	Assemble Ducts, Rotary Valves, Windows, Thermal Exp. Joints	10
ID Fan	Parameters established, Initiate RFQs, Purchase, Install	90
ID Fan Variable Speed Drive (VSD)	Parameters established, Initiate RFQs, Purchase, Install	100
Lower Loop Seal Flow Control	Determine required control properties	5
Upper Loop Seal Flow Control	Determine required control properties	5
Secondary Combustion Air Blowers	Confirm Parameters, Initiate RFQs, Purchase	100
Secondary Air Variable Speed Drives (VSD)	Establish Parameters, Initiate RFQs, Purchase, Install	100
Secondary Air Control Valves	Establish Parameters, Initiate RFQs, Purchase, Install	70
Ash Bunker Auger	Specify Auger Design, Order, Install	40

Ash Bunker Auger Drive	Confirm Parameters, Initiate RFQs, Purchase, Install	**40**
Ash Bunker Auger Power Supply	Establish Parameters, Initiate RFQs, Purchase, Install	**20**
Ash Supply Auger Tube	Determine if on site, proceed from this finding	**5**
Ash Supply Bunker Auger	Mass Flow establised, Establish other Parameters, Intiate RFQs	**10**
Flue Duct: Secondary Cyclone to ID Fan	Duct: Design, Specify, Purchase, Install	**35**
ID Fan Discharge Duct	Duct: Design, Specify, Purchase, Install	**70**
Lower Loop Seal Flow Control	Provide controlled compressed air, piping & computer control	**5**
Upper Loop Seal Flow Control	Provide controlled compressed air, piping & computer control	**5**
Pressure & Temperature Sensors	Specify Components, Purchase	**70**
Rotary Air Lock Valve Drives	Determine Locations, Specify, Initiate RFQs, Purchase	**10**
Rotary Air Lock Valve Drive Power Supplies	Parameters established, Initiate RFQs, Purchase, Install	**80**
Fuel Duct Window for Flow Proving Sensors	Complete Design, Acquire Materials,Construct	**10**
Secondary Combustion Air Blowers	Establish locations for each, Install	**70**
Secondary Combustion Air VSD	Parameters established, Initiate RFQs, Purchase, Install	**100**
Secondary Air Blower Power Supplies	Parameters established, Initiate RFQs, Purchase, Install	**100**
Supply Bunker Augers (3 ea.)	Mass Flow establised, Establish other Parameters, Intiate RFQs	**10**
Supply Transverse Auger	Mass Flow establised, Establish other Parameters, Intiate RFQs	**10**
Supply Transverse Auger Power Supply	Establish parameters, initiate RFQs	**50**
Supply Bunker Auger Drive Power Supplies	Parameters established, Initiate RFQs, Purchase, Install	**10**
Power Supplies for all Computer Interfaces	Determine Location, Specify, Initiate RFQs, Purchase	**5**
Un-used Ports	Identify & Specify Closures for all	**5**
Ash Bunker Auger Drive Control	Signal cable, conduit: Specify, Purchase, Install	**10**
Ash Bunker Auger Drive Control Interface	Install in Enclosure, connect control & data cable	**5**
Ash Bunker Auger Drive Interface Enclosure	Determine Location, Specify, Purchase, Install	**5**
Ash Supply Bunker Support	Develop Support Design, Acquire Materials,Construct	**20**
Bubble Plate Refractory Molding	Research geometry & materials; Apply to Plate; Assemble Plate	**40**
Cargo Lift System	Complete Design, Purchase Supplies, Construct	**30**
FD Fan VSD Control	Signal cable, conduit: Specify, Purchase, Install	**5**
FD Fan VSD Control Interface	Install in Enclosure, connect control & data cable	**5**
Fluidizing Air/Bed Preheater	Parameters established, Initiate RFQs, Purchase, Install	**70**
ID Fan Control	Computer Control & Display Program	**85**
ID Fan VSD Control	Signal cable, conduit: Specify, Purchase, Install	**5**
ID Fan VSD Control Interface	Install in Enclosure, connect control & data cable	**5**
ID Fan VSD Control Interface Enclosure	Determine Location, Specify, Purchase, Install	**5**
Pressure & Temperature Sensors	Modify Riser Ports/ Surrounding Floor Frame, Install	**15**
Rotary Air Lock Valve Drive Controls	Signal cable, conduit: Specify, Purchase, Install	**5**
Rotary Air Lock Valve Drive Interfaces	Install in Enclosure, connect control & data cable	**5**
Rotary Valve Drive Interface Enclosures	Determine Location, Specify, Purchase, Install	**5**
Secondary Air Blower Controls	Computer Control & Display Program	**85**
Secondary Air Blower VSD Controls	Signal cable, conduit: Specify, Purchase, Install	**5**
Secondary Air Blower VSD Control Interfaces	Install in Enclosure, connect control & data cable	**5**
Sec. Air Blower Control Interface Enclosures	Determine Location, Specify, Purchase, Install	**5**
Secondary Air Blower Discharge Ducts	Specify material(s), size, locations	**50**
Sensor Signal	Signal cable, conduit: Specify, Purchase, Install	**5**
Sensor Signal Interface	Install in Enclosure, connect control & data cable	**5**
Sensor Signal Interface Enclosure	Determine Locations, Specify, Purchase, Install	**5**
Windbox & Ash Drain	Determine Ash Drain Sliding Seal Design, Assemble Windbox	**70**
Fluidizing Air Supply	Assemble flexible duct from Blower Duct to Windbox inlet	**80**

Supply Bunker Supports	Complete Design, Purchase Supplies, Construct	**20**
Supply Bunker Augers (3 ea.)	Install Augers, Seals & Support Bearings	**10**
Supply Transverse Auger Drive	Parameters established, Initiate RFQs, Purchase, Install	**10**
Transverse Auger Tube to Rotary Valve Adpt.	Design and Construct corrected adapter allowing connection	**10**
All Other Sensors	Parameters established, Initiate RFQs	**40**
Supply Bunker Auger Tubes Assembly	Determine if on site, proceed from this finding	**10**
Supply Bunker Auger Drive Interfaces	Install in Enclosure, connect control & data cable	**10**
Supply Bunker Auger Drive Interface Encl.	Determine Location, Specify, Purchase, Install	**10**
Supply Flow Proving Sensors	Design Complete, Specify Components…	**20**
Supply Transverse Auger	Install Auger, Seal & Support Bearings	**10**
Supply Transverse Auger Tube	Determine if on site, proceed from this finding	**0**
Supply Transverse Auger Drive Controls	Signal cable, conduit: Specify, Purchase, Install	**10**
Supply Transverse Auger Drive Interfaces	Install in Enclosure, connect control & data cable	**10**
Supply Transverse Auger Drive Interface Encl.	Determine Location, Specify, Purchase, Install	**10**
Visual Display of all other Process Variables	Design Complete, Specify Components…	**75**
Process Meas. & Control System	Correct/Modify as Required; Otherwise nearly Complete	**95**
Ash (Hot & Cold) Supply Ducts	All Ash Ducts on site	**100**
Ash Supply Bunker	Ash Supply Bunker on site	**100**
Fuel/Bed Material Supply Ducts	All Supply Ducts on site	**100**
Rotary Air Lock Valves, Motors (2 ea.)	All Rotary Valves, Motors on site	**100**
Supply Bunker Auger Drive Controls	All Supply Drive Controls on site	**100**
Supply Bunker Auger Drives (3 ea.)	All Supply Drives on site	**100**
Supply Bunker Load Cells	All Load Cells on site	**100**
Supply Bunkers	All Supply Bunkers on site	**100**
Heat Exchangers	Coolant control Valves: Specify, Purchase, Install	**70**

2.2 Experimental Study of Air Pollutant Emissions by Optimized Combustion in a Laboratory-Scale Incinerator

2.2.1 Incinerator

A laboratory-scale tube flow incinerator was used to evaluate the combustion performance of waste pellets and the resulting emissions. A photograph of the tube flow incinerator is shown in Figure 1. The incinerator is made of a 2″ I.D. stainless steel pipe and is a 4-foot long. A thermocouple is inserted into the reactor to monitor the internal temperature. Considering that high temperature is desirable for the decomposition of long carbon chain organics, a two-stage furnace with a two-channel temperature controller is used to heat the incinerator. Thus, the desired temperature can be achieved at different locations inside the incinerator. During incineration with waste pellets, temperature in the upper part of the incinerator is maintained higher than that at the bottom part in order to decompose Volatile Organic Compounds (VOC) and Semi-volatile Organic Compounds

(Semi-VOC) with the high carbon dioxide (CO_2) concentration off gas generated by high heating rates. The testing samples were waste material which had been used for gas generator of vehicle air bag. They look like small balls and the diameter falls in the range of 2 mm. During incineration, two waste pellet samples (called NQ-AD and QB-B) were fed into the incinerator in individual tests by a mini screw feeder at a rate of 3.9 g/min. Air is blown into the incinerator with an excess air ratio of 1.8 to ensure better incineration. The incineration conditions are shown as follows:

Feeding rate: 3.9 g/min;
Air: 10 l/min (minimum air flow rate for complete incineration is 5.5 l/min);
Temperature: 800 ˚C (top); 600 ˚C (bottom);

Figure 1. Photograph of the laboratory-scale waste incinerator

2.2.2 Instrumentation and Flue Gas Monitor

The gaseous products exit the outlet at the top end of the incinerator to instrument or sampling trains. All sampling lines are made of Teflon material to prevent contamination and ensure measurement accuracy. An IMR5000 gas analyzer, as shown in Figure 2, is used to monitor the flue gas composition including oxygen (O_2), methane (CH_4), ammonia (NH_3), hydrogen sulfide (H_2S), hydrogen chloride (HCl), carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), chlorine (Cl_2), nitrogen monoxide (NO) and nitrogen dioxide (NO_2). NO_x (NO, NO_2) species was also sampled by an impinger train, which is analyzed by DX-120 Ion Chromatograph Analyzer based on EPA Method 7d.

Figure 2. IMR5000 flue gas monitor

2.2.3 EPA Methods Sampling Train

The determination of Particulate Matter (PM) emission rates is based on EPA Method 17. EPA Method 29, as shown in Figure 3, is used to characterize gaseous trace metals (arsenic, chromium, cadmium, lead, iron, mercury, nickel, silver, copper and strontium). EPA method 1311 (Toxicity Characteristic Leaching Procedure, TCLP) is used to characterize trace metals by Inductively Coupled Plasma - Atomic Emission Spectrometer (ICP-AES) for all metals except mercury. Leeman cold-vapor atomic absorption (CVAA) is used for mercury determination. EPA Method 0030 and Method 0010, as shown in Figures 4 and 5, are used to characterize VOCs and Semi-VOCs, respectively. VOC analysis includes benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethene, methyl ethyl ketone, tetrachloroethene, trichloroethene, and vinyl chloride. Semi-volatile organic compounds include cresols, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, nitrobenzene, pentachlorophenol, pyridine, 2,4,5-trichlorophenol, and 2,4,6-trichlorophenol. Volatile and semi-volatile organic compounds in particulate matter and burn residue are analyzed according to EPA Method 1311. The detailed EPA methods used for these characterizations are listed in Table 2.

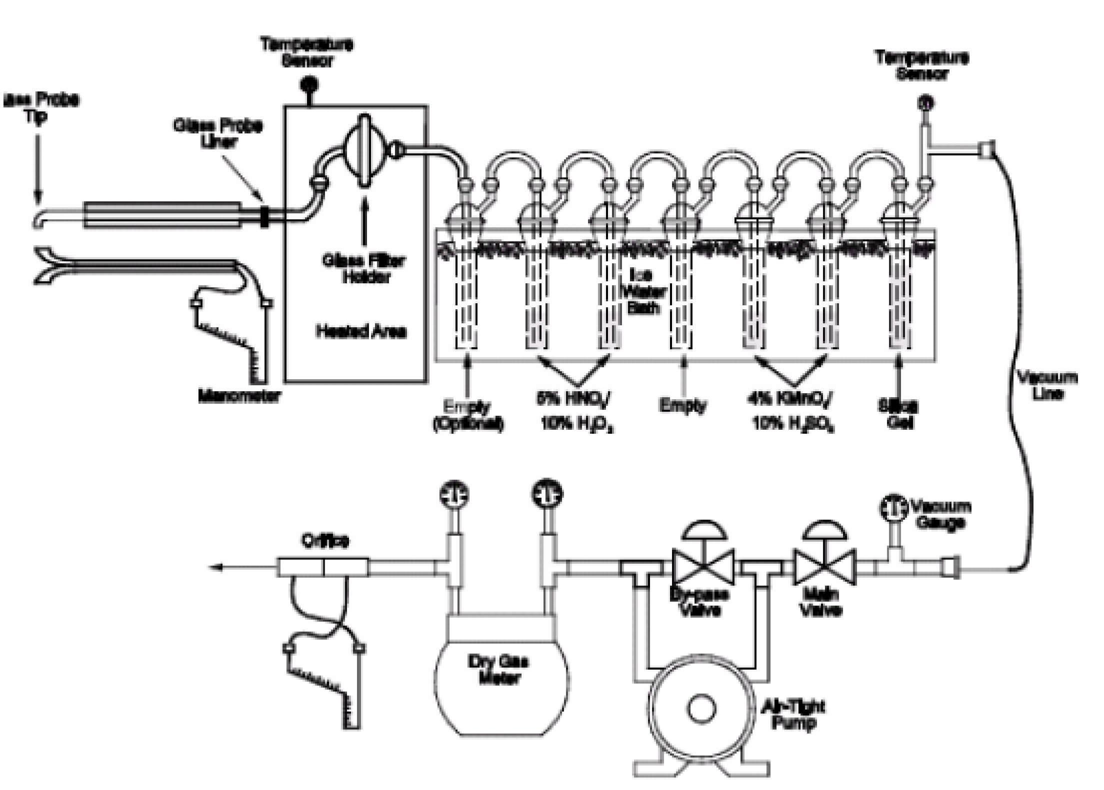

Figure 3. EPA Method 29 for trace metals sampling

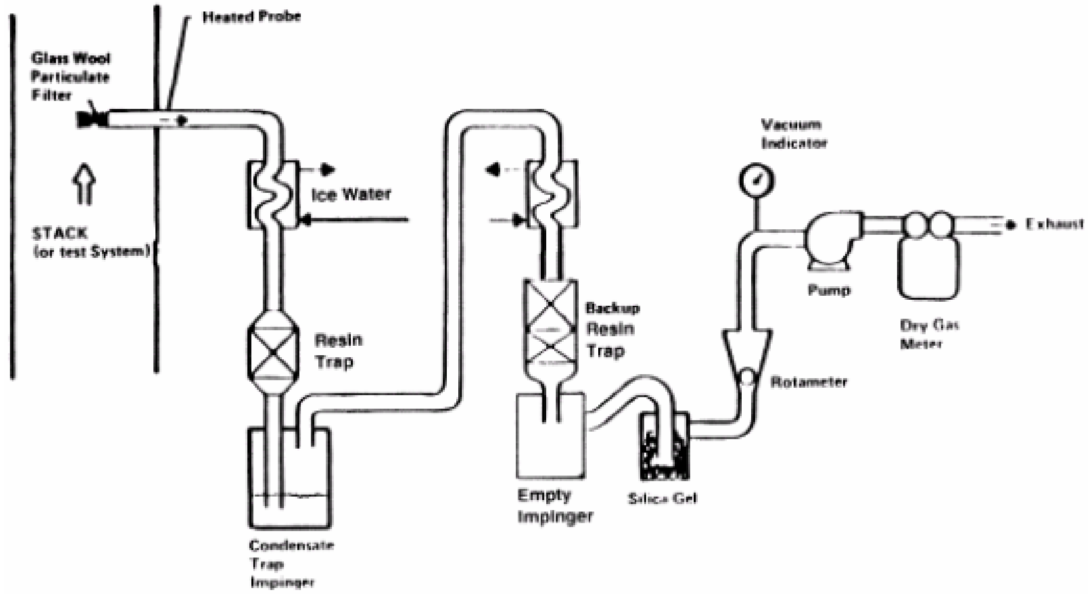

Figure 4. EPA Method 0033 for VOC sampling

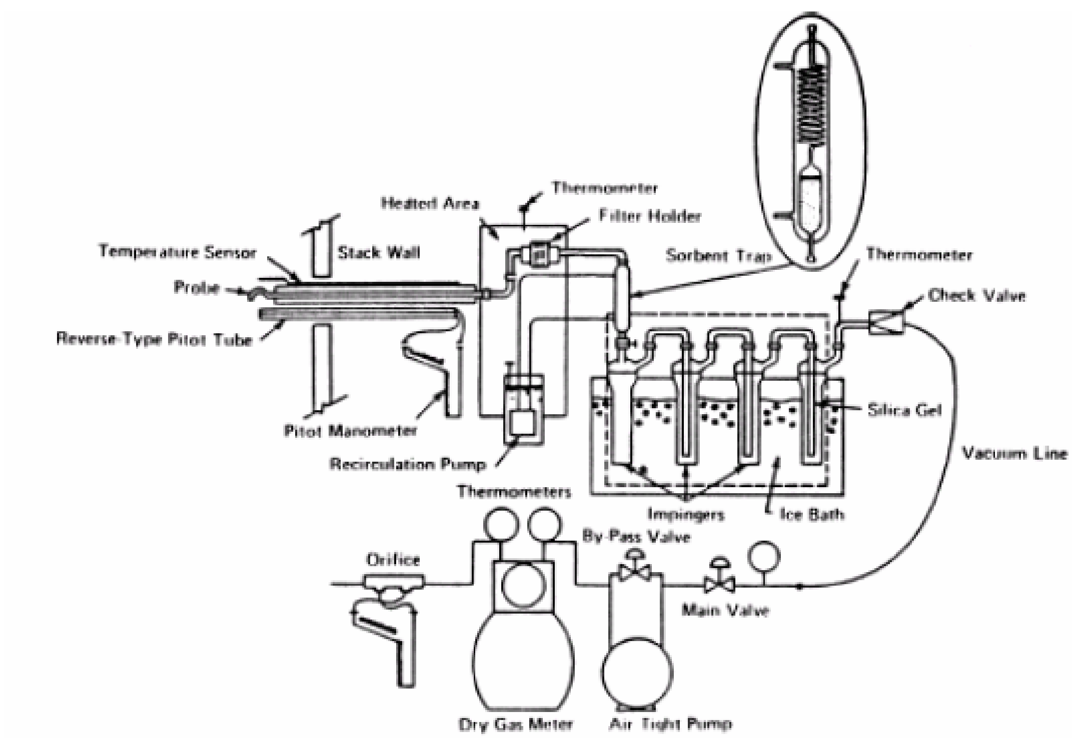

Figure 5. EPA Method 0011 for semi-VOC sampling

Table 2. Lists of EPA Methods used

EPA Methods			
Trace metals			
	Off gas	**Fly ash**	**Bottom ash**
Sampling	EPA M-29	EPA M-29	Grab sampling method
Sample extraction	-	EPA TCLP 1311	EPA TCLP 1311
Analysis	EPA 200.7	EPA 200.7	EPA 200.7
VOC			
	Off gas	**Fly ash**	**Bottom ash**
Sampling	EPA 0030	Grab Sampling Method	Grab Sampling Method
Sample extraction	EPA Thermal desorbtion Method 5041	EPA TCLP 1311	EPA TCLP 1311
Analysis	8260 B	8260 B	8260 B
Semi-VOC			
	Off gas	**Fly ash**	**Bottom ash**
Sampling	EPA 0010	Grab Sampling Method	Grab Sampling Method
Sample extraction	EPA 3541	EPA TCLP 1311	EPA TCLP 1311
Analysis	EPA 8270 D	EPA 8270 D	EPA 8270 D

3. RESULTS AND DISCUSSION

3.1 Gaseous Air Pollutants Generated during Tests in the Laboratory-Scale Incinerator

Results from the laboratory-scale waste incinerator indicate that nitrogen species are the main air pollutants generated during incineration of waste pellets. Table 3 presents the emission results for nitrogen species. Results indicated that sample QB-B emits a higher concentration of nitrogen compounds than sample NQ-AD. For example, NO and NO_2 emissions from sample QB-B varied between 2000-2200 ppm and 530-570 ppm, respectively, versus 520-550 ppm of NO and 530-570 ppm of NO_2 for sample NQ-AD. However, N_2O emissions from sample QB-B is lower between 245-267 ppm, than that from sample NQ-AD, which ranged between 880-1013 ppm. NH_3, CO, and CH_4 were not detected because excess air is provided to maintain complete incineration during test. These compounds typically exist in an oxygen limited environment, which was not an issue in this work.

The emission rates of gaseous VOCs is largely controlled, as shown in Table 4. The majority of the VOC species are less than the detection limit, except for benzene. The benzene emission rate varied from 0.47 μg (0.27+0.209 for trap 1 and trap 2 in series) to 1.031 μg (0.78+0.251 for trap 1 and trap 2 in series) for the sample NQ-AD, and from

1.041 μg to 1.41 μg for the sample QB-B. Methane ethyl ketone present at a level of 0.5 μg is found during incineration of the sample QB-B, but not for parallel testing with sample NQ-AD. Benzene levels can be easily controlled by increasing reactor temperature (high combustion temperature with sufficient oxygen will reduce the formation of benzene). An open combustion configuration could produce less (<1 μg) benzene than was found in this work. Test results for all gaseous semi-VOCs are found to be less than the detection limit (0.01 μg) for all semi-VOC compounds specified in EPA Method 0011. The specific semi-VOCs should be completely decomposed during the incineration process.

Table 3. Emissions of Gaseous Air Pollutants

	Nitrogen species			
	NO	NO_2	N_2O	NH_3
	In ppm			
NQ-AD	518-546	229-236	879-1013	ND
QB-B	2020-2211	529-567	245-267	ND
	Other combustion source species			
	CO	CH_4	SO_2	HCl
NQ-AD	ND	ND	ND	ND
QB-B	ND	ND	ND	ND

Notes: Estimated product gas generation = 3L/g raw waste pellet, thus, 1 NM3/0.33Kg raw waste pellets

Table 4. Emissions of Gaseous VOC

	Units	VOST-BLANK	RDL	QC Batch	VOC-1 NQ AD-1 9/17/06	RDL	QC Batch
Vinyl Chloride	ug	ND	0.01	1056763	ND	0.1	1057747
1,1-Dichloroethane	ug	ND	0.01	1056763	ND	0.1	1057747
Chloroform	ug	ND	0.01	1056763	ND	0.1	1057747
1,2-Dichloroethane	ug	ND	0.007	1056763	ND	0.07	1057747
Methyl Ethyl Ketone (2-Butanone)	ug	ND	0.04	1056763	ND	0.4	1057747
Carbon Tetrachloride	ug	ND	0.02	1056763	ND	0.2	1057747
Benzene	ug	0.015	0.009	1056763	0.78	0.09	1057747
Trichloroethylene	ug	ND	0.01	1056763	ND	0.1	1057747
Tetrachloroethylene	ug	ND	0.02	1056763	ND	0.2	1057747
Chlorobenzene	ug	ND	0.01	1056763	ND	0.1	1057747
Surrogate Recovery (%)							
Bromofluorobenzene	%	96	N/A	1056763	71	N/A	1057747
D4-1,2-Dichloroethane	%	103	N/A	1056763	74	N/A	1057747
D8-Toluene	%	96	N/A	1056763	78	N/A	1057747

ND = Not detected
N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

	Units	VOC-1 NQ AD-2 9/17/06	RDL	QC Batch	VOC-2 QA ND-1 9/17/06	RDL	QC Batch
Vinyl Chloride	ug	ND	0.01	1057747	ND	0.1	1058299
1,1-Dichloroethane	ug	ND	0.01	1057747	ND	0.1	1058299
Chloroform	ug	ND	0.01	1057747	ND	0.1	1058299
1,2-Dichloroethane	ug	ND	0.007	1057747	ND	0.07	1058299
Methyl Ethyl Ketone (2-Butanone)	ug	ND	0.04	1057747	ND	0.4	1058299
Carbon Tetrachloride	ug	ND	0.02	1057747	ND	0.2	1058299
Benzene	ug	0.251	0.009	1057747	0.27	0.09	1058299
Trichloroethylene	ug	ND	0.01	1057747	ND	0.1	1058299
Tetrachloroethylene	ug	ND	0.02	1057747	ND	0.2	1058299
Chlorobenzene	ug	ND	0.01	1057747	ND	0.1	1058299
Surrogate Recovery (%)							
Bromofluorobenzene	%	94	N/A	1057747	84	N/A	1058299
D4-1,2-Dichloroethane	%	100	N/A	1057747	108	N/A	1058299
D8-Toluene	%	94	N/A	1057747	99	N/A	1058299

ND = Not detected
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RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

	Units	VOC-2 QA ND-2 9/17/06	RDL	VOC-1 QB-B-1 9/17/06	RDL	QC Batch
Vinyl Chloride	ug	ND	0.01	ND	0.1	1057747
1,1-Dichloroethane	ug	ND	0.01	ND	0.1	1057747
Chloroform	ug	ND	0.01	ND	0.1	1057747
1,2-Dichloroethane	ug	ND	0.007	ND	0.07	1057747
Methyl Ethyl Ketone (2-Butanone)	ug	ND	0.04	ND	0.4	1057747
Carbon Tetrachloride	ug	ND	0.02	ND	0.2	1057747
Benzene	ug	0.209	0.009	0.67	0.09	1057747
Trichloroethylene	ug	ND	0.01	ND	0.1	1057747
Tetrachloroethylene	ug	ND	0.02	ND	0.2	1057747
Chlorobenzene	ug	ND	0.01	ND	0.1	1057747
Surrogate Recovery (%)						
Bromofluorobenzene	%	98	N/A	79	N/A	1057747
D4-1,2-Dichloroethane	%	94	N/A	97	N/A	1057747
D8-Toluene	%	97	N/A	91	N/A	1057747

ND = Not detected
N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

	Units	VOC-1 QB-B-2 9/17/06	RDL	QC Batch	VOC-2 QB-B-1&2 9/17/06	RDL	QC Batch
Vinyl Chloride	ug	ND	0.01	1057747	ND	0.1	1058299
1,1-Dichloroethane	ug	ND	0.01	1057747	ND	0.1	1058299
Chloroform	ug	0.03	0.01	1057747	ND	0.1	1058299
1,2-Dichloroethane	ug	ND	0.007	1057747	ND	0.07	1058299
Methyl Ethyl Ketone (2-Butanone)	ug	ND	0.04	1057747	0.5	0.4	1058299
Carbon Tetrachloride	ug	ND	0.02	1057747	ND	0.2	1058299
Benzene	ug	0.371	0.009	1057747	1.48	0.09	1058299
Trichloroethylene	ug	ND	0.01	1057747	ND	0.1	1058299
Tetrachloroethylene	ug	ND	0.02	1057747	ND	0.2	1058299
Chlorobenzene	ug	ND	0.01	1057747	ND	0.1	1058299
Surrogate Recovery (%)							
Bromofluorobenzene	%	107	N/A	1057747	95	N/A	1058299
D4-1,2-Dichloroethane	%	95	N/A	1057747	111	N/A	1058299
D8-Toluene	%	92	N/A	1057747	105	N/A	1058299

ND = Not detected
N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

3.2 TCLP Pollutants in Fly Ash and Bottom Ash Generated During Tests in the Laboratory-Scale Incinerator

The fly ash and bottom ash from samples NQ-AD and QB-B were subjected to TCLP analysis for trace metals, VOCs and semi-VOCs. It is found that trace metals, VOCs and semi-VOCs in the fly ash are always undetectable or very close to the instrument (ICP-MS, GC-MS) detection limits. Tables 5 and 6 list the results for trace metals, Table 7 lists the results for VOC leachate in fly ash, and Table 8 lists the results for semi-VOCs in fly ash by TCLP.

Table 5. Trace Metals in Fly Ash from Waste Pellets after Incineration by TCLP

Trace metals in Fly ash	Si	Sr	Ag	Fe	As	Cd	Cr	Cu	Ni	Pb	Hg
unit						ppm					ppb
NQ-AD (100 grams fly ash subjected to TCLP procedure with 2000 ml extraction solution)	13.8	1309	0.028	0.006	UD	UD	UD	0.161	0.542	UD	1.5
QB-B Fly Ash (3 grams fly ash subjected to TCLP procedure with 60 ml extraction solution)	33.2	18	0.007	UD	UD	UD	UD	0.033	0.175	UD	1.7
Detection limit, in ppb	1.4	0.01	5	3	9.3	3	0.15	0.3	0.3	5.8	0.1

Note: 1. Not enough fly ash of Sample QB-B can be generated as equired because of fly ash emission is very low

2. Estimated generation rate of fly ash from Sample NQ-AD = 0.065g/g raw waste pellet, thus, 100g fly ash/1.5Kg raw waste pellets

3. Estimated generation rate of fly ash from Sample QB-B = 0.0026g/g raw waste pellet, thus, 100g fly ash/40Kg raw waste pellets

4. Sampling:EPA method 29, TCLP: EPA method 1311, Analysis: EPA 200.7

Table 6. Trace Metals in Bottom Ash from Waste Pellets after Incineration by TCLP

Trace metals in Bottom ash	Si	Sr	Ag	Fe	As	Cd	Cr	Cu	Ni	Pb	Hg
unit						ppm					ppb
NQ-AD Bottom ash(100 grams bottom ash subjected to TCLP procedure with 2000 ml extraction solution)	219	574	0.012	0.009	UD	UD	UD	0.041	0.191	UD	0.67
QB-B Bottom Ash (100 grams bottom ash subjected to TCLP procedure with 2000 ml extraction solution)	8.67	7.8	UD	0.007	UD	UD	UD	0.181	0.174	UD	0.46
Detection limit						ppb					
	1.4	0.01	5	3	9.3	3	0.15	0.3	0.3	5.8	0.1

Note: 1. Estimated generation rate of bottom ash from Sample NQ-AD = 0.935g/g raw waste pellet, thus, 100g bottom ash/0.107Kg raw waste pellets

2. Estimated generation rate of bottom ash from Sample QB-B = 0.997g/g raw waste pellet, thus, 100g bottom ash/0.1003Kg raw waste pellets

3. Sampling:EPA method 29, TCLP: EPA method 1311, EPA 200.7

Table 7. VOC in Fly Ash from Waste Pellets after Incineration by TCLP

QB-B fly ash	Method	Results	Unit	Detection limit
1,1-Dichloroethene	EPA 8260 B	0.05, UD	mg/l	0.05
1,2-Dichloroethane	EPA 8260 B	0.05, UD	mg/l	0.05
2-Butanone	EPA 8260 B	0.05, UD	mg/l	0.05
Benzene	EPA 8260 B	0.05, UD	mg/l	0.05
Carbon Tetrachloride	EPA 8260 B	0.05, UD	mg/l	0.05
Chlorobenzene	EPA 8260 B	0.05, UD	mg/l	0.05
Chloroform	EPA 8260 B	0.05, UD	mg/l	0.05
Tetrachloroethene	EPA 8260 B	0.05, UD	mg/l	0.05
Trichloroethene	EPA 8260 B	0.05, UD	mg/l	0.05
Vinyl Chloride	EPA 8260 B	0.05, UD	mg/l	0.05

NQ-AD fly ash	Method	Results	Unit	Detection limit
1,1-Dichloroethene	EPA 8260 B	0.05, UD	mg/l	0.05
1,2-Dichloroethane	EPA 8260 B	0.05, UD	mg/l	0.05
2-Butanone	EPA 8260 B	0.05, UD	mg/l	0.05
Benzene	EPA 8260 B	0.05, UD	mg/l	0.05
Carbon Tetrachloride	EPA 8260 B	0.05, UD	mg/l	0.05
Chlorobenzene	EPA 8260 B	0.05, UD	mg/l	0.05
Chloroform	EPA 8260 B	0.05, UD	mg/l	0.05
Tetrachloroethene	EPA 8260 B	0.05, UD	mg/l	0.05
Trichloroethene	EPA 8260 B	0.05, UD	mg/l	0.05
Vinyl Chloride	EPA 8260 B	0.05, UD	mg/l	0.05

Table 8. Semi-VOC in Fly Ash from Waste Pellets after Incineration by TCLP

QB-B fly ash	Method	Results	Unit	Detection limit
1,4-Dichlorobenzene	EPA 8270 D	UD	mg/l	0.05
2,4-Dinitrotoluene	EPA 8270 D	UD	mg/l	0.05
Hexachlorobenzene	EPA 8270 D	UD	mg/l	0.05
Hexachlorobutadiene	EPA 8270 D	UD	mg/l	0.05
Hexachloroethane	EPA 8270 D	UD	mg/l	0.05
Nitrobenzene	EPA 8270 D	UD	mg/l	0.05
Pentachlorophenol	EPA 8270 D	UD	mg/l	0.05
Pyridine	EPA 8270 D	UD	mg/l	0.05
2,4,5-Trichlorophenol	EPA 8270 D	UD	mg/l	0.05
2,4,6-Trichlorophenol	EPA 8270 D	UD	mg/l	0.05

NQ-AD fly ash	Method	Results	Unit	Detection limit
1,4-Dichlorobenzene	EPA 8270 D	UD	mg/l	0.05
2,4-Dinitrotoluene	EPA 8270 D	UD	mg/l	0.05
Hexachlorobenzene	EPA 8270 D	UD	mg/l	0.05
Hexachlorobutadiene	EPA 8270 D	UD	mg/l	0.05
Hexachloroethane	EPA 8270 D	UD	mg/l	0.05
Nitrobenzene	EPA 8270 D	UD	mg/l	0.05
Pentachlorophenol	EPA 8270 D	UD	mg/l	0.05
Pyridine	EPA 8270 D	UD	mg/l	0.05
2,4,5-Trichlorophenol	EPA 8270 D	UD	mg/l	0.05
2,4,6-Trichlorophenol	EPA 8270 D	UD	mg/l	0.05

4. CONCLUSIONS

During this quarter, the following progress has been made:

a) The installation of CFBC Facility was continued. All ash recirculation ducts have been aligned and installed. Both loop seals have been installed in ash recirculation path. Cold ash supply duct has been installed. Installation of the induced draft fan power supply and variable speed drive has been completed. Wind box installation has been completed. Deliveries of some parts were delayed and proposed tests were be postponed accordingly.

b) A laboratory-scale waste incineration test was conducted with two waste pellets and various emissions were measured.

5. FUTURE WORK AND UPDATED SCHEDULE

5.1 Future Work

During the next quarter, work will focus on the following activities:

a) Install one remaining thermal expansion joint below the lower loop seal.

b) Design, order components and install pneumatic control elements and signal lines for loop seal operation.

c) Install cold ash bunker and transport auger, drive, power supply and control.

d) Install induced draft fan, including support structure.

e) Install flue gas ductwork between secondary cyclone and ID fan inlet and flue duct on discharge side of ID fan.

f) Install secondary combustion air fan, fabricate distribution duct work and install secondary air flow control valves and their control elements.

g) Specify, order and install pressure and flow transducers, modifying some ports where building support structure interferes.

h) Design, specify, purchase and install sensor and control signal interface hub enclosures within combustor tower facility. Install digital data lines from these hubs to the process control computer.

i) Install control elements for pneumatic operation of primary combustion/fluidizing air diverter valve operation.

j) Complete flexible duct, power supply, control elements and enclosure installation for bed pre-heater operation.

k) Perform so called "leak test" or cold fluidization test to confirm proper operation of sub-systems from the combustion/fluidization air supply to the induced fan. For this test, pressure and flow sensors will be in operation. CFBC ash obtained from another commercial facility will be used in this test.

5.2 Project Schedule

Based on the current status of the project, the project schedule for the remainder work is shown in Table 9.

Table 9. Project schedule

Task	Schedule
Install induced draft fan and flue ducts to and from; construct machine base mount	February 15, 2007
Install one remaining thermal expansion joint on ash duct below lower loop seal	February 15, 2007
Install both loop seal operators and control lines	February 15, 2007
Install ash transport auger, seals and bearings, gear motor, variable speed drive, power supply, control interface	February 15, 2007
Perform leak test of System	February 15, 2007
Install three gravimetric supply bunkers and associated supply duct components.	April 30, 2007
Install secondary combustion air fan and distribution duct work; control interface	April 30, 2007
Complete ordering and installation of coolant system components	June 30, 2007

Complete specification, ordering of components and installation of water treatment system for heat exchanger coolant loop	June 30, 2007
Complete specification and installation of sensors and control operators	July 31, 2007
Complete process control and data acquisition computer program development	August 31 2007
Complete the installation of the CFBC Facility	August 31, 2007
Based on the experimental data obtained from the laboratory-scale CFBC Facility, determine the optimal conditions for co-firing waste materials with high sulfur coals in the CFBC Facility.	September 30, 2007
Complete the study to determine the effect of air staging, fuel feeding position, and limestone feeding on the gaseous emissions in the CFBC Facility.	September 30, 2007
Complete the investigation of mercury emissions from co-firing of waste materials with high sulfur coal in the CFBC Facility	September 30, 2007
Submit final report	October 31, 2007

ACRONYMS AND ABBREVIATIONS

CFBC Circulating Fluidized-Bed Combustion

DOE U.S. Department of Energy

ECTL Environmental Control Technology Laboratory

ISCET Institute for Combustion Science and Environmental Technology

VOC Volatile Organic Compounds

semi-VOC Semi-volatile Organic Compounds

TCLP Toxicity Characteristic Leaching Procedure